CROSS-REFERENCE TO RELATED APPLICATIONS

[1] Foreign Application Priority Data

Aug 23, 1988[AU]	PI9983

Current U.S. Class:	220/6; 220/1.5
Intern'l Class:	B65D 007/26
Field of Search:	220/6,1.5,4.28

References Cited [Referenced By]

U.S. Patent Documents

3570698	Mar., 1971	Dougherty	220/1.
3602388	Aug., 1971	Hurkamp	220/6.
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4088238	May., 1978	Berwald et al.	220/1.
4214669	Jul., 1980	McQuiston	220/6.
4360115	Nov., 1982	Saunders	220/1.
4577772	Mar., 1986	Bigliardi	220/6.
4848613	Jul., 1989	Yuan et al.	220/1.

4858779	Aug., 1989	Zimmerlund	220/6.
5190179	Mar., 1993	Richter et al	220/6.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

Not Applicable

REFERENCE TO SEQUENCE LISTING, A TABLE, OR A COMPUTER PROGRAM LISTING COMPACT DISK APPENDIX

Not Applicable

BACKGROUND OF THE INVENTION

1.Field of the Invention

[2] The present invention is directed to the empty cargo container repositioning in the logistics industry.

2.Prior Art

[3] Trades among different continents create the need for the empty cargo container repositioning. Take the trade between North America and Asia as an example; cargo containers are fully loaded with goods manufactured in Asia when transported from Asia to North America; however, most of those cargo containers are empty when transported

from North America back to Asia. The empty cargo container repositioning is fairly costly because it involves similar operations as the loaded one during its transportation from one location to another. Therefore, it is in the logistics industry's interest to have a container, which can be disassembled into component parts, the component parts can be converted to cargo during its empty repositioning. To this end, many forms of collapsible containers have been proposed in the past, and a selection of the most pertinent prior art is embodied in the following patent specifications: U.S. Pat. No. 3398850, U.S. Pat. No. 3529741, U.S. Pat. No. 3570698, U.S. Pat. No. 3765556, U.S. Pat. No. 3796342, U.S. Pat. No. 4177907, U.S. Pat. No. 4214669, U.S. Pat. No. 4388995, U.S. Pat. No. 4577772, U.S. Pat. No. 5190179 and AU-A-68129/87.

[4] For the logistics industry to accept a collapsible container, however, a container structure must be proved to be sound; the container disassembling and assembling process has to be simple and can be automated easily; the empty container repositioning reduction has to be effective. All those prior art containers are consisted of too many component parts, as a result, the containers could not meet the rigid structure requirement. Furthermore, all those prior art containers entirely overlooked the dissembling and assembling process automation which is an important key for a collapsible container acceptance. That is why there is no collapsible container has been endorsed by the logistics industry so far.

BRIEF SUMMARY OF THE INVENTION

[5] The present invention designs a collapsible cargo container consisting of six component frame panels; the six component frame panels are a floor frame panel, a

ceiling frame panel, two identical front and back frame panels, a right frame panel where the doors located and a left frame panel. Through connectors attached to each component frame panel, the collapsible cargo container can be effectively dissembled and assembled. During empty cargo container repositioning, each empty collapsible cargo container is disassembled into six component frame panels, and the component frame panels are loaded into shipping collapsible cargo containers, then shipped to a destination. After the shipping collapsible cargo containers arrive at the destination, the disassembled component frame panels will remain in the shipping collapsible cargo containers until needed. Furthermore, disassembled 20-foot collapsible cargo container panels can be connected through special connectors to form equivalent disassemble 40-foot collapsible cargo container panels, then loaded into 40-foot collapsible cargo containers as cargo to increase the empty cargo container repositioning efficiency

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING

[6] The foregoing summary and the following detailed description may be better understood when read in conjunction with the accompanying drawings. Various embodiments are shown for the purpose of illustrating the invention. It is understood, however, that this invention is not limited to the precise arrangements shown. A drawings identification is based on the cargo container type, that is, figure 3A represents a 40 foot cargo container drawing; figure 3B represents a 40 foot high cube cargo container drawing; figure 3C represents a 20 foot cargo container drawing; figure 3D represents a 20 foot high cube cargo container drawing; figure 33A/B represents a drawing for 40 foot cargo container and 40 foot high cube cargo container; FIG 33C/D represents a drawing for 20

foot cargo container and 20 foot high cube cargo container; FIG 39A/C/D represents a drawing for 40 foot cargo container, 20 foot cargo container and 20 foot high cube cargo container; FIG 54 represents a drawing for all type container. Furthermore, a floor frame panel coat, a ceiling frame panel coat, a front frame panel coat, a back frame panel coat, a left frame panel coat and two right frame panel doors are not presented in drawings in order to show the invention clearly.

[7] Figure 1A ("Drawings" page 1) shows a basic isometric view of the 40 foot collapsible cargo container loaded with three disassembled 40 foot collapsible cargo container frames. This container is referred as "shipping collapsible cargo container".

[8] Figure 2A ("Drawings" page 2) shows a detailed isometric view of the 40 foot collapsible cargo container loaded with three disassembled 40 foot collapsible cargo container frames.

[9] Figure 3A ("Drawings" page 3) shows a basic isometric view of the 40 foot collapsible cargo container frame.

[10] Figure 4A ("Drawings" page 4) shows an enlarged isometric view of the left end of a 40 foot collapsible cargo container.

[11] Figure 5A ("Drawings" page 5) shows an opaque isometric view of the 40 foot collapsible cargo container frames.

[12] Figure 6A ("Drawings" page 6) shows a basic isometric view of the floor frame (40 foot collapsible cargo container).

[13] Figure 7A ("Drawings" page 7) shows an opaque isometric view of the floor frame (40 foot collapsible cargo container)

[14] Figure 8A ("Drawings" page 8) shows an isometric view of the left end of the floor frame (40 foot collapsible cargo container).

[15] Figure 9A ("Drawings" page 9) shows a top view of the left end of a floor frame (40 foot collapsible cargo container).

[16] Figure 10A ("Drawings" page 10) shows a front view of the left end of a floor frame (40 foot collapsible cargo container).

[17] Figure 11A ("Drawings" page 10) shows a left view of a floor frame (40 foot collapsible cargo container).

[18] Figure 12A ("Drawings" page 11) shows an isometric view of the right end of a floor frame (40 foot collapsible cargo container).

[19] Figure 13A ("Drawings" page 12) shows a top view of the right end of a floor frame (40 foot collapsible cargo container).

[20] Figure 14A ("Drawings" page 13) shows a front view of the right end of a floor frame (40 foot collapsible cargo container).

[21] Figure 15A ("Drawings" page 13) shows a right view of a floor frame (40 foot collapsible cargo container).

[22] Figure 16A ("Drawings" page 14) shows an isometric view of a ceiling frame (40 foot collapsible cargo container).

[23] Figure 17A ("Drawings" page 15) shows an isometric view of the left end of a ceiling frame (40 foot collapsible cargo container).

[24] Figure 18A ("Drawings" page 16) shows a top view of the left end of a ceiling frame (40 foot collapsible cargo container).

[25] Figure 19A ("Drawings" page 17) shows a front view of the left end of a ceiling frame (40 foot collapsible cargo container).

[26] Figure 20A ("Drawings" page 17) shows a left view of a ceiling frame (40 foot collapsible cargo container).

[27] Figure 21A ("Drawings" page 18) shows an isometric view of the right end of a ceiling frame (40 foot collapsible cargo container).

[28] Figure 22A ("Drawings" page 19) shows a top view of the right end of a ceiling frame (40 foot collapsible cargo container).

[29] Figure 23A ("Drawings" page 20) shows a front view of the right end of a ceiling frame (40 foot collapsible cargo container).

[30] Figure 24A ("Drawings" page 20) shows a right view of a ceiling frame (40 foot collapsible cargo container).

[31] Figure 25A ("Drawings" page 21) shows isometric views of a left frame (40 foot collapsible cargo container).

[32] Figure 26A ("Drawings" page 22) shows an Isometric internal view of the corner of a left frame (40 foot collapsible cargo container).

[33] Figure 27A ("Drawings" page 23) shows an internal view of a left frame (40 foot collapsible cargo container).

[34] Figure 28A ("Drawings" page 24) shows an external view of a left frame (40 foot collapsible cargo container).

[35] Figure 29A ("Drawings" page 25) shows isometric views of a right frame (40 foot collapsible cargo container).

[36] Figure 30A ("Drawings" page 26) shows an isometric internal view of the corner of a right frame (40 foot collapsible cargo container).

[37] Figure 31A ("Drawings" page 27) shows an internal view of a right frame (40 foot collapsible cargo container).

[38] Figure 32A ("Drawings" page 28) shows an external view of a right frame (40 foot collapsible cargo container).

[39] Figure 33A/B ("Drawings" page 29) shows an isometric view of the front/back frame (40 foot and 40 foot high cube cargo containers).

[40] Figure 34A/B ("Drawings" page 30) shows an isometric view of the top corner of a front/back frame (40 foot and 40 foot high cube cargo containers).

[41] Figure 35A ("Drawings" page 31) shows an isometric view of a floor frame that contains a front frame and a back frame (40 foot collapsible cargo container).

[42] Figure 36A ("Drawings" page 32) shows an isometric view of a ceiling frame stacked on top of a floor frame that contains a front frame and a back frame (40 foot collapsible cargo container), which is referred as "collapsible cargo container frame panel assembly".

[43] Figure 37 ("Drawings" page 33) shows an isometric view of the base part, which is used to prevent the direct contact between "collapsible cargo container frame panel assembly" and "shipping floor frame panel", which is defined in Figure 39A/C/D and Figure 39B.

[44] Figure 38 ("Drawings" page 34) shows an enlarged front view of a loaded collapsible cargo container that is also referred as shipping container. The shaded lines indicate

the base part. The base parts are placed on top of the shipping container's floor frame base at both ends to support the disassembled frame panels

[45] Figure 39A/C/D ("Drawings" page 35) shows a 40 foot shipping collapsible cargo container floor frame panel referred as "shipping floor frame panel", related front and back frame panels are stored in "shipping floor frame panel", a base part is placed on each end of "shipping floor frame panel".

[46] Figure 40A/C/D("Drawings" page 36) is an enlarged view based on Figure 39A/C/D to show the base part position indicated by shaded lines.

[47] Figure 41A("Drawings" page 37) shows that first "collapsible cargo container frame panel assembly" is stacked on top of previous assembly during disassemble and load process.

[48] Figure 42A("Drawings" page 38) shows that second "collapsible cargo container frame panel assembly" is stacked on top of previous assembly during disassemble and load process.

[49] Figure 43A("Drawings" page 39) shows that third "collapsible cargo container frame panel assembly" is stacked on top of previous assembly during disassemble and load process.

[50] Figure 44A("Drawings" page 40) shows that left and right frames from 2 disassembled cargo containers are stacked on top of the previous assembly during disassemble and load process.

[51] Figure 45A("Drawings" page 41) shows that left frame of the shipping collapsible cargo container is assembled during disassemble and load process.

[52] Figure 46A("Drawings" page 42) shows that right frame of the shipping collapsible cargo container is assembled during disassemble and load process.

[53] Figure 47A("Drawings" page 43) shows that ceiling frame of the shipping collapsible cargo container is assembled during disassemble and load process.

[54] Figure 48A("Drawings" page 44) shows that six vertical beams are assembled during disassemble and load process.

[55] Figure 1B ("Drawings" page 45) shows a basic isometric view of the 40 foot high cube collapsible cargo container loaded with two disassembled 40 foot high cube collapsible cargo container frames. This container is referred as "shipping collapsible cargo container".

[56] Figure 2B ("Drawings" page 46) shows a detailed isometric view of the 40 foot high cube collapsible cargo container loaded with two disassembled 40 foot high cube collapsible cargo container frames.

[57] Figure 3B ("Drawings" page 47) shows a basic isometric view of the 40 foot high cube collapsible cargo container frame.

[58] Figure 4B ("Drawings" page 48) shows an enlarged isometric view of the left end of a 40 foot high cube collapsible cargo container.

[59] Figure 5B ("Drawings" page 49) shows an opaque isometric view of the 40 foot high cube collapsible cargo container frames.

[60] Figure 6B ("Drawings" page 50) shows a basic isometric view of the floor frame (40 foot high cube collapsible cargo container).

[61] Figure 7B ("Drawings" page 51) shows an opaque isometric view of the floor frame (40 foot high cube collapsible cargo container).

[62] Figure 8B ("Drawings" page 52) shows an isometric view of the left end of the floor frame (40 foot high cube collapsible cargo container).

[63] Figure 9B ("Drawings" page 53) shows a top view of the left end of a floor frame (40 foot high cube collapsible cargo container).

[64] Figure 10B ("Drawings" page 54) shows a front view of the left end of a floor frame (40 foot high cube collapsible cargo container).

[65] Figure 11B ("Drawings" page 54) shows a left view of a floor frame (40 foot high cube collapsible cargo container).

[66] Figure 12B ("Drawings" page 55) shows an isometric view of the right end of a floor frame (40 foot high cube collapsible cargo container).

[67] Figure 13B ("Drawings" page 56) shows a top view of the right end of a floor frame (40 foot high cube collapsible cargo container).

[68] Figure 14B ("Drawings" page 57) shows a front view of the right end of a floor frame (40 foot high cube collapsible cargo container).

[69] Figure 15B ("Drawings" page 57) shows a right view of a floor frame (40 foot high cube collapsible cargo container).

[70] Figure 16B ("Drawings" page 58) shows an isometric view of a ceiling frame (40 foot high cube collapsible cargo container).

[71] Figure 17B ("Drawings" page 59) shows an isometric view of the left end of a ceiling frame (40 foot high cube collapsible cargo container).

[72] Figure 18B ("Drawings" page 60) shows a top view of the left end of a ceiling frame (40 foot high cube collapsible cargo container).

[73] Figure 19B ("Drawings" page 61) shows a front view of the left end of a ceiling frame (40 foot high cube collapsible cargo container).

[74] Figure 20B ("Drawings" page 61) shows a left view of a ceiling frame (40 foot high cube collapsible cargo container).

[75] Figure 21B ("Drawings" page 62) shows an isometric view of the right end of a ceiling frame (40 foot high cube collapsible cargo container).

[76] Figure 22B ("Drawings" page 63) shows a top view of the right end of a ceiling frame (40 foot high cube collapsible cargo container).

[77] Figure 23B ("Drawings" page 64) shows a front view of the right end of a ceiling frame (40 foot high cube collapsible cargo container).

[78] Figure 24B ("Drawings" page 64) shows a right view of a ceiling frame (40 foot high cube collapsible cargo container).

[79] Figure 25B ("Drawings" page 65) shows isometric views of a left frame (40 foot high cube collapsible cargo container).

[80] Figure 26B ("Drawings" page 66) shows an Isometric internal view of the corner of a left frame (40 foot high cube collapsible cargo container).

[81] Figure 27B ("Drawings" page 67) shows an internal view of a left frame (40 foot high cube collapsible cargo container).

[82] Figure 28B ("Drawings" page 68) shows an external view of a left frame (40 foot high cube collapsible cargo container).

[83] Figure 29B ("Drawings" page 69) shows isometric views of a right frame (40 foot high cube collapsible cargo container).

[84] Figure 30B ("Drawings" page 70) shows an isometric internal view of the corner of a right frame (40 foot high cube collapsible cargo container).

[85] Figure 31B ("Drawings" page 71) shows an internal view of a right frame (40 foot high cube collapsible cargo container).

[86] Figure 32B ("Drawings" page 72) shows an external view of a right frame (40 foot high cube collapsible cargo container).

[87] Figure 35B ("Drawings" page 73) shows an isometric view of a floor frame that contains a front frame and a back frame (40 foot high cube collapsible cargo container).

[88] Figure 36B ("Drawings" page 74) shows an isometric view of a ceiling frame stacked on top of a floor frame that contains a front frame and a back frame (40 foot high cube collapsible cargo container), which is referred as "collapsible cargo container frame panel assembly".

[89] Figure 39B ("Drawings" page 75) shows that front and back frames of the shipping collapsible cargo container are stored in its own floor frame, and a base part is placed at each end during disassemble and load process. And this 40 foot high cube shipping collapsible cargo container floor frame panel is now referred as "shipping floor frame panel".

[90] Figure 40B("Drawings" page 76) is an enlarged view based on figure 39B to show the base part position indicated by shaded lines.

[91] Figure 41B("Drawings" page 77) shows that first "collapsible cargo container frame panel assembly" is stacked on top of previous assembly during disassemble and load process.

[92] Figure 42B("Drawings" page 78) shows that second "collapsible cargo container frame panel assembly" is stacked on top of previous assembly during disassemble and load process.

[93] Figure 43B("Drawings" page 79) shows left and right frames from 2 disassembled cargo containers are stacked on top of the previous assembly during disassemble and load process.

[94] Figure 44B("Drawings" page 80) shows that left frame of the shipping collapsible cargo container is assembled during disassemble and load process.

[95] Figure 45B("Drawings" page 81) shows that right frame of the shipping collapsible cargo container is assembled during disassemble and load process.

[96] Figure 46B("Drawings" page 82) shows that ceiling frame of the shipping collapsible cargo container is assembled during disassemble and load process.

[97] Figure 47B("Drawings" page 83) shows that six vertical beams are assembled during disassemble and load process.

[98] Figure 1C ("Drawings" page 84) shows a basic isometric view of the 40 foot collapsible cargo container loaded with six disassembled 20 foot collapsible cargo container frames. This container is referred as "shipping collapsible cargo container".

[99] Figure 2C ("Drawings" page 85) shows a detailed isometric view of the 40 foot collapsible cargo container loaded with six disassembled 20 foot collapsible cargo container frames.

[100] Figure 3C ("Drawings" page 86) shows a basic isometric view of the 20 foot collapsible cargo container frame.

[101] Figure 4C ("Drawings" page 87) shows an enlarged isometric view of the left end of a 20 foot collapsible cargo container.

[102] Figure 6C ("Drawings" page 88) shows a basic isometric view of the floor frame (20 foot collapsible cargo container).

[103] Figure 12C ("Drawings" page 89) shows an isometric view of the right end of a floor frame (20 foot collapsible cargo container).

[104] Figure 13C ("Drawings" page 90) shows a top view of the right end of a floor frame (20 foot collapsible cargo container).

[105] Figure 14C ("Drawings" page 91) shows a front view of the right end of a floor frame (20 foot collapsible cargo container).

[106] Figure 15C ("Drawings" page 91) shows a right view of a floor frame (20 foot collapsible cargo container).

[107] Figure 16C ("Drawings" page 92) shows an isometric view of a ceiling frame (20 foot collapsible cargo container).

[108] Figure 21C ("Drawings" page 93) shows an isometric view of the right end of a ceiling frame (20 foot collapsible cargo container).

[109] Figure 22C ("Drawings" page 94) shows a top view of the right end of a ceiling frame (20 foot collapsible cargo container).

[110] Figure 23C ("Drawings" page 95) shows a front view of the right end of a ceiling frame (20 foot collapsible cargo container).

[111] Figure 24C ("Drawings" page 95) shows a right view of a ceiling frame (20 foot collapsible cargo container).

[112] Figure 25C ("Drawings" page 96) shows isometric views of a left frame (20 foot collapsible cargo container).

[113] Figure 26C ("Drawings" page 97) shows an Isometric internal view of the corner of a left frame (20 foot collapsible cargo container).

[114] Figure 27C ("Drawings" page 98) shows an internal view of a left frame (20 foot collapsible cargo container).

[115] Figure 28C ("Drawings" page 99) shows an external view of a left frame (20 foot collapsible cargo container).

[116] Figure 29C ("Drawings" page 100) shows isometric views of a right frame (20 foot collapsible cargo container).

[117] Figure 30C ("Drawings" page 101) shows an isometric internal view of the corner of a right frame (20 foot collapsible cargo container).

[118] Figure 31C ("Drawings" page 102) shows an internal view of a right frame (20 foot collapsible cargo container).

[119] Figure 32C ("Drawings" page 103) shows an external view of a right frame (20 foot collapsible cargo container).

[120] Figure 33C/D ("Drawings" page 104) shows an isometric view of the front/back frame (20 foot and 20 foot high cube cargo containers).

[121] Figure 34C/D ("Drawings" page 105) shows an isometric view of the top corner of a front/back frame (20 foot and 20 foot high cube cargo containers).

[122] Figure 35C ("Drawings" page 106) shows an Isometric view of connected floor frame that contains two front frames and two back frames (20 foot collapsible cargo container).

[123] Figure 36C ("Drawings" page 107) shows an Isometric view of connected ceiling frames stacked on top of connected floor frames. Each connected floor frame contains two front frames and two back frames (20 foot collapsible cargo container). This assembly is referred as "collapsible cargo container frame panel assembly".

[124] Figure 41C ("Drawings" page 108) shows that first "collapsible cargo container frame panel assembly" is stacked on top of previous assembly shown in Figure 39A/C/D during disassemble and load process.

[125] Figure 42C ("Drawings" page 109) shows that second "collapsible cargo container frame panel assembly" is stacked on top of previous assembly during disassemble and load process.

[126] Figure 43C ("Drawings" page 110) shows that third "collapsible cargo container frame panel assembly" is stacked on top of previous assembly during disassemble and load process.

[127] Figure 44C ("Drawings" page 111) shows that left and right frames from 2 disassembled 20 foot collapsible cargo containers are stacked on top of the previous assembly during disassemble and load process.

[128] Figure 45C ("Drawings" page 112) shows that left frame of the 40 foot shipping collapsible cargo container is assembled during disassemble and load process.

[129] Figure 46C ("Drawings" page 113) shows that right frame of the 40 foot shipping collapsible cargo container is assembled during disassemble and load process.

[130] Figure 47C ("Drawings" page 114) shows that ceiling frame of the 40 foot shipping collapsible cargo container is assembled during disassemble and load process.

[131] Figure 48C ("Drawings" page 115) shows that six vertical beams are assembled during disassemble and load process.

[132] Figure 49C ("Drawings" page 116) shows that two connectors connect two ceiling frame panels during the shipping process (20 foot collapsible cargo container).

[133] Figure 50C ("Drawings" page 117) shows a detail view based on Figure 49C.

[134] Figure 51C ("Drawings" page 118) shows that two connectors connect two floor frame panels during the shipping process (20 foot collapsible cargo container).

[135] Figure 52C ("Drawings" page 119) shows a detail view based on Figure 51C.

[136] Figure 53C ("Drawings" page 120) shows two connectors used to connect two floor frame panels as well as two ceiling frame panels (20 foot collapsible cargo container).

[137] Figure 1D ("Drawings" page 121) shows a basic isometric view of the 40 foot collapsible cargo container loaded with four disassembled 20 foot high cube collapsible cargo container frames. This container is referred as "shipping collapsible cargo container".

[138] Figure 2D ("Drawings" page 122) shows a detailed isometric view of the 40 foot collapsible cargo container loaded with four disassembled 20 foot high cube collapsible cargo container frames.

[139] Figure 3D ("Drawings" page 123) shows a basic isometric view of the 20 foot high cube collapsible cargo container frame.

[140] Figure 4D ("Drawings" page 124) shows an enlarged isometric view of the left end of a 20 foot high cube collapsible cargo container.

[141] Figure 6D ("Drawings" page 125) shows a basic isometric view of the floor frame (20 foot high cube collapsible cargo container).

[142] Figure 12D ("Drawings" page 126) shows an isometric view of the right end of a floor frame (20 foot high cube collapsible cargo container).

[143] Figure 13D ("Drawings" page 127) shows a top view of the right end of a floor frame (20 foot high cube collapsible cargo container).

[144] Figure 14D ("Drawings" page 128) shows a front view of the right end of a floor frame (20 foot high cube collapsible cargo container).

[145] Figure 15D ("Drawings" page 128) shows a right view of a floor frame (20 foot high cube collapsible cargo container).

[146] Figure 16D ("Drawings" page 129) shows an isometric view of a ceiling frame (20 foot high cube collapsible cargo container).

[147] Figure 21D ("Drawings" page 130) shows an isometric view of the right end of a ceiling frame (20 foot high cube collapsible cargo container).

[148] Figure 22D ("Drawings" page 131) shows a top view of the right end of a ceiling frame (20 foot high cube collapsible cargo container).

[149] Figure 23D ("Drawings" page 132) shows a front view of the right end of a ceiling frame (20 foot high cube collapsible cargo container).

[150] Figure 24D ("Drawings" page 132) shows a right view of a ceiling frame (20 foot high cube collapsible cargo container).

[151] Figure 25D ("Drawings" page 133) shows isometric views of a left frame (20 foot high cube collapsible cargo container).

[152] Figure 26D ("Drawings" page 134) shows an Isometric internal view of the corner of a left frame (20 foot high cube collapsible cargo container).

[153] Figure 27D ("Drawings" page 135) shows an internal view of a left frame (20 foot high cube collapsible cargo container).

[154] Figure 28D ("Drawings" page 136) shows an external view of a left frame (20 foot high cube collapsible cargo container).

[155] Figure 29D ("Drawings" page 137) shows isometric views of a right frame (20 foot high cube collapsible cargo container).

[156] Figure 30D ("Drawings" page 138) shows an isometric internal view of the corner of a right frame (20 foot high cube collapsible cargo container).

[157] Figure 31D ("Drawings" page 139) shows an internal view of a right frame (20 foot high cube collapsible cargo container).

[158] Figure 32D ("Drawings" page 140) shows an external view of a right frame (20 foot high cube collapsible cargo container).

[159] Figure 35D ("Drawings" page 141) shows an Isometric view of connected floor frame that contains two front frames and two back frames (20 foot high cube collapsible cargo container).

[160] Figure 36D ("Drawings" page 142) shows an Isometric view of connected ceiling frames stacked on top of connected floor frames. Each connected floor frame contains two front frames and two back frames (20 foot high cube collapsible cargo container). This assembly is referred as "collapsible cargo container frame panel assembly".

[161] Figure 41D ("Drawings" page 143) shows that first "collapsible cargo container frame panel assembly" is stacked on top of the shipping frame panel (shown in FIG. 39A/C/D) during disassemble and load process.

[162] Figure 42D ("Drawings" page 144) shows that second "collapsible cargo container frame panel assembly" is stacked on top of previous assembly during disassemble and load process.

[163] Figure 43D ("Drawings" page 145) shows that left and right frames from 2 disassembled 20 foot high cube collapsible cargo containers are stacked on top of the previous assembly during disassemble and load process.

[164] Figure 44D ("Drawings" page 146) shows that left frame of the 40 foot shipping collapsible cargo container is assembled during disassemble and load process.

[165] Figure 45D ("Drawings" page 147) shows that right frame of the 40 foot shipping collapsible cargo container is assembled during disassemble and load process.

[166] Figure 46D ("Drawings" page 148) shows that ceiling frame of the 40 foot shipping collapsible cargo container is assembled during disassemble and load process.

[167] Figure 47D ("Drawings" page 149) shows that six vertical beams are assembled during disassemble and load process.

[168] Figure 49D ("Drawings" page 150) shows that two connectors connect two ceiling frame panels during the shipping process (20 foot high cube collapsible cargo container)

[169] Figure 50D ("Drawings" page 151) shows a detail view based on Figure 49D.

[170] Figure 51D ("Drawings" page 152) shows that two connectors connect two floor frame panels during the shipping process (20 foot high cube collapsible cargo container).

[171] Figure 52D ("Drawings" page 153) shows a detail view based on Figure 51D.

[172] Figure 53D ("Drawings" page 154) shows two connectors used to connect two floor frame panels as well as two ceiling frame panels (20 foot high cube collapsible cargo container).

[173] Figure 54 ("Drawings" page 155) is the female pin base that is part of the floor/ceiling frame panel; it is used to connect with the male pin base that is part of the front/back frame panel.

[174] Figure 55 ("Drawings" page 155) is the male pin base; it locks the front/back frame panel and the floor/ceiling frame panel together.

[175] Figure 56 ("Drawings" page 155) is the joint T pin holder that is part of the right/left frame panel; it is used to connect with the joint T pin that is part of the floor/ceiling frame panel.

[176] Figure 57 ("Drawings" page 155) is the joint T pin; it locks the floor/ceiling frame panel and the right/left frame panel together.

[177] Figure 58A/B ("Drawings" page 156) shows the frame panel structure model (40 foot collapsible cargo container).

[178] Figure 59 ("Drawings" page 156) shows those I-Beams, [-Beams and []-Beams used to construct the collapsible cargo container frame panel structure.

[179] Figure 60A/B ("Drawings" page 156) shows the front/back frame panel structure model (40 foot collapsible cargo container).

[180] Figure 61A/B ("Drawings" page 157) shows the modified front/back frame panel structure model consisted of only three vertical columns (40 foot collapsible cargo container).

[181] Figure 62 ("Drawings" page 157) shows the collapsible cargo container left frame vertical column section view.

[182] Figure 63 ("Drawings" page 157) shows the collapsible cargo container right frame vertical column section view.

[183] Figure 64A/B ("Drawings" page 158) shows the floor frame panel structure model (40 foot collapsible cargo container).

[184] Figure 65A/B ("Drawings" page 158) shows the ceiling frame panel structure model (40 foot collapsible cargo container).

[185] Figure 66A/B ("Drawings" page 158) shows the frame panel structure load conditions (40 foot collapsible cargo container).

[186] Figure 67A/B ("Drawings" page 159) shows the frame panel under the centralized load at the four floor longitude beam corners as well as its weight load (40 foot collapsible cargo container).

[187] Figure 68A ("Drawings" page 159) shows the frame panel structure deformation graph under 44,452kg distributed load and 3,088 kg weight (40 foot collapsible cargo container simply supported at the four floor corners).

[188] Figure 69A ("Drawings" page 160) shows the frame panel structure deformation graph under 29,871 distributed load and 3,088 kg weight (40 foot collapsible cargo container simply supported at the four floor corners).

[189] Figure 70A ("Drawings" page 160) shows the frame panel structure deformation graph under 22,221kg load at the four floor corners and 3,088 kg weight load (40 foot collapsible cargo container simply supported at the four floor corners).

[190] Figure 71A ("Drawings" page 161) shows the frame panel structure deformation graph under 44,452kg distributed load and 3,088 kg weight (40 foot collapsible cargo container simply supported at the four ceiling corners).

[191] Figure 72A ("Drawings" page 161) shows the frame panel structure deformation graph under 29,871 distributed load and 3,088 kg weight (40 foot collapsible cargo container simply supported at the four ceiling corners).

[192] Figure 73A ("Drawings" page 162) shows the frame panel structure deformation graph under 22,221kg load at the four floor corners and 3,088 kg weight load (40 foot collapsible cargo container simply supported at the four ceiling corners).

[193] Figure 68B ("Drawings" page 162) shows the frame deformation graph under 44,452kg distributed load and 3,117 kg weight (40 foot high cube collapsible container simply supported at the four floor corners).

[194] Figure 69B ("Drawings" page 163) shows the frame deformation graph under 29,871 distributed load and 3,117 kg weight (40 foot high cube collapsible container simply supported at the four floor corners).

[195] Figure 70B ("Drawings" page 163) shows the frame deformation graph under 22,221kg load at the four floor corners and 3,117 kg weight load (40 foot high cube collapsible container simply supported at the four floor corners).

[196] Figure 71B ("Drawings" page 164) shows the frame deformation graph under 44,452kg distributed load and 3,117 kg weight (40 foot high cube collapsible container simply supported at the four top corners).

[197] Figure 72B ("Drawings" page 164) shows the frame deformation graph under 29,871kg distributed load and 3,117 kg weight (40 foot high cube collapsible container simply supported at the four top corners).

[198] Figure 73B ("Drawings" page 165) shows the frame deformation graph under 22,221kg load at the four floor corners and 3,117 kg weight load (40 foot high cube collapsible container simply supported at the four top corners).

[199] Figure 58C/D ("Drawings" page 165) shows the frame panel structure model (20 foot collapsible cargo container).

[200] Figure 60C/D ("Drawings" page 166) shows the front/back frame panel structure model (20 foot collapsible cargo container).

[201] Figure 61C/D ("Drawings" page 166) shows the modified front/back frame consisted only by one vertical column (20 foot collapsible cargo container).

[202] Figure 64C/D ("Drawings" page 166) shows the floor frame panel structure model (20 foot collapsible cargo container).

[203] Figure 65C/D ("Drawings" page 167) shows the ceiling frame panel structure model (20 foot collapsible cargo container).

[204] Figure 66C/D ("Drawings" page 167) shows the distributed load and weight load (20 foot collapsible cargo container).

[205] Figure 67C/D ("Drawings" page 168) shows the frame under a centralized load at the four floor beam corners as well as its weight load (20 foot collapsible cargo container).

[206] Figure 68C ("Drawings" page 168) shows the frame deformation graph under 44,452kg distributed load and 1891kg weight (20 foot collapsible cargo container simply supported at the four floor corners).

[207] Figure 69C ("Drawings" page 169) shows the frame deformation graph under 29,871kg distributed load and 1891kg weight (20 foot collapsible cargo container simply supported at the four floor corners).

[208] Figure 70C ("Drawings" page 169) shows the frame deformation graph under 22,221kg load at the four floor beam corners and 1891kg weight load (20 foot collapsible cargo container simply supported at the four floor corners).

[209] Figure 71C ("Drawings" page 170) shows the frame deformation graph under 44,452kg distributed load and 1891kg weight (20 foot collapsible cargo container simply supported at the four top corners).

[210] Figure 72C ("Drawings" page 170) shows the frame deformation graph under 29,871 distributed load and 1891kg weight (20 foot collapsible cargo container simply supported at the four top corners).

[211] Figure 73C ("Drawings" page 171) shows the frame deformation graph under 22,221kg load at the four floor beam corners and 1891kg weight load (20 foot collapsible cargo container simply supported at the four top corners).

[212] Figure 68D ("Drawings" page 171) shows the frame deformation graph under 44,452kg distributed load and 1936kg weight (20 foot high cube collapsible container simply supported at the four floor corners).

[213] Figure 69D ("Drawings" page 172) shows the frame deformation graph under 29,871 distributed load and 1936kg weight (20 foot high cube collapsible container simply supported at the four floor corners).

[214] Figure 70D ("Drawings" page 172) shows the frame deformation graph under 22,221kg load at the four floor beam corners and 1936kg weight load (20 foot high cube collapsible container simply supported at the four floor corners).

[215] Figure 71D ("Drawings" page 173) shows the frame deformation graph under 44,452kg distributed load and 1936kg weight (20 foot high cube collapsible container simply supported at the four top corners).

[216] Figure 72D ("Drawings" page 173) shows the frame deformation graph under 29,871kg distributed load and 1936kg weight (20 foot high cube collapsible container simply supported at the four top corners).

[217] Figure 73D ("Drawings" page 174) shows the frame deformation graph under 22,221kg load at the four floor beam corners and 1936kg weight load (20 foot high cube collapsible container simply supported at the four top corners).

[218] Figure 74 ("Drawings" page 174) shows the joint T pin holder and its load condition.

[219] Figure 75 ("Drawings" page 175) shows the floor level joint T pin holder stress contour graph.

[220] Figure 76 ("Drawings" page 175) shows the ceiling level joint T pin holder stress contour graph.

[221] Figure 77 ("Drawings" page 176) shows the joint T pin holder detail analysis.

[222] Figure 78 ("Drawings" page 177) shows the joint T pin holder detail stress contour graph at the floor level.

[223] Figure 79 ("Drawings" page 177) shows the joint T pin holder detail stress contour graph at the ceiling level.

[224] Figure 80 ("Drawings" page 178) shows the male pin base.

[225] Figure 81 ("Drawings" page 178) shows the male pin base finite element model and load.

[226] Figure 82 ("Drawings" page 179) shows the male pin base stress contour graph.

[227] Figure 83 ("Drawings" page 179) shows the male pin base deformation graph of X-orientation.

[228] Figure 84 ("Drawings" page 180) shows the male pin base deformation graph of Y-orientation.

[229] Figure 85 ("Drawings" page 180) shows the female pin base.

[230] Figure 86 ("Drawings" page 181) shows the female pin base finite element model and load.

[231] Figure 87 ("Drawings" page 181) shows the female pin base stress contour graph.

[232] Figure 88 ("Drawings" page 182) shows the female pin base deformation graph of X-orientation.

[233] Figure 89 ("Drawings" page 182) shows the female pin base deformation graph of Y-orientation.

[234] Table 1A ("Drawings" page 183) shows the inner force of the cross beams in the front/back frame panel structure as shown in figure 60A/B (40 foot collapsible cargo container).

[235] Table 1B ("Drawings" page 183) shows the inner forces of the cross beams in the front/back frame panel structure as shown in figure 60A/B (40 foot high cube collapsible cargo container).

[236] Table 1C ("Drawings" page 184) shows the inner forces of the cross beams in the front/back frame panel structure as shown in figure 60C/D (20 foot collapsible cargo container).

[237] Table 1D ("Drawings" page 184) shows the inner forces of the cross beams in the front/back frame panel structure as shown in figure 60C/D (20 foot high cube collapsible cargo container).

[238] Table 2A ("Drawings" page 184) shows the inner forces of the vertical beams as shown in figure 61A/B (40 foot collapsible cargo container).

[239] Table 2B ("Drawings" page 185) shows the inner forces of the vertical beams as shown in figure 61A/B (40 foot high cube collapsible cargo container).

[240] Table 2C ("Drawings" page 185) shows the inner forces of the vertical beams as shown in figure 61C/D (20 foot collapsible cargo container).

[241] Table 2D ("Drawings" page 185) shows the inner forces of the vertical beams as shown in figure 61C/D (20 foot high cube collapsible cargo container).

DETAILED DESCRIPTION OF THE INVENTION

1. The collapsible cargo container

[242] The collapsible cargo container consists of six-component frame panels:

- Floor frame panel as shown in figure 6A, figure 6B, figure 6C and figure 6D.
- Ceiling frame panel as shown in figure 16A, figure 16B, figure 16C and figure 16D.
- Left frame panel as shown in figure 25A, figure 25B, figure 25C and figure 25D.
- Right frame panel as shown in figure 29A, figure 29B, figure 29C and figure 29D.
- Front panel as shown in figure 33A/B and figure 33C/D.
- Back panel as shown in figure 33A/B and figure 33C/D.

Each of the six component frame panels is composed of steel beams. Additionally, there are two steel columns in the right and left frame panels, and a steel plate in the 40 foot cargo container floor frame panel. The characteristics of the steel beam, steel column and steel plate are described in detail in the next section titled 'The collapsible cargo container frame panel structure analysis'.

[243] The six component frame panels of the collapsible cargo container are assembled together through their connectors:

- The female pin base connector as shown in figure 54
- The male pin base connector as shown in figure 55
- The joint T pin holder as shown in figure 56
- The joint T pin as shown in figure 57

The female pin base connector and male pin base connector are used to assemble the floor frame panel, the front/back frame panels, and the ceiling frame panel together. The joint T pin holder and joint T pin are used to assemble the right/left frame panels and the floor/ceiling frame panels together.

[244] For the 40 foot collapsible cargo container, 10 female pin base connectors are attached to the floor frame panel as shown in figure 6A, figure 8A and figure 12A. 10 female pin base connectors are attached to the ceiling frame panel as shown in figure 16A, figure 17A and figure 21A. 10 male pin base connectors are attached to the front frame panel as shown in figure 33A/B and figure 34A/B. 10 male pin base connectors are attached to the back frame panel as shown in figure 33A/B and figure 34A/B. 8 joint T pin holders

are attached to the left frame panels as shown in figure 25A and figure 26A. 8 joint T pin holders are attached to the right frame panels as shown in figure 29A and figure 30A. There are 4 joint T pins on each side of the floor frame panel as shown in figure 6A, figure 8A and figure 12A. There are 4 joint T pins on each side of the ceiling frame panel as shown in figure 16A, figure 17A and figure 21A. The complete 40 foot collapsible cargo container assembly is shown in figure 3A.

[245] For the 40 foot high cube collapsible cargo container, 10 female pin base connectors are attached to the floor frame panel as shown in figure 6B, figure 8B and figure 12B. 10 female pin base connectors are attached to the ceiling frame panel as shown in figure 16B, figure 17 B and figure 21B. 10 male pin base connectors are attached to the front frame panel as shown in figure 33A/B and figure 34A/B. 10 male pin base connectors are attached to the back frame panel as shown in figure 33A/B and figure 34A/B. 8 joint T pin holders are attached to the left frame panels as shown in figure 25B and figure 26B. 8 joint T pin holders are attached to the right frame panels as shown in figure 29B and figure 30B. There are 4 joint T pins on each side of the floor frame panel as shown in figure 6B, figure 8B and figure 12B. There are 4 joint T pins on each side of the ceiling frame panel as shown in figure 16B, figure 17B and figure 21B. The complete 40 foot high cube collapsible cargo container assembly is shown in figure 3B.

[246] For the 20 foot collapsible cargo container, 6 female pin base connectors are attached to the floor frame panel as shown in figure 6C, and figure 12C. 6 female pin base connectors are attached to the ceiling frame panel as shown in figure 16C, and figure 21C. 6 male pin base connectors are attached to the front frame panel as shown in figure 33C/D and figure 34C/D. 6 male pin base connectors are attached to the back

frame panel as shown in figure 33C/D and figure 34C/D. 8 joint T pin holders are attached to the left frame panels as shown in figure 25C and figure 26C. 8 joint T pin holders are attached to the right frame panels as shown in figure 29C and figure 30C. There are 4 joint T pins on each side of the floor frame panel as shown in figure 6C, figure 12C. There are 4 joint T pins on each side of the ceiling frame panel as shown in figure 16C, and figure 21C. The complete 20 foot collapsible cargo container assembly is shown in figure 3C.

[247] For the 20 foot high cube collapsible cargo container, 6 female pin base connectors are attached to the floor frame panel as shown in figure 6D, and figure 12D. 6 female pin base connectors are attached to the ceiling frame panel as shown in figure 16D, and figure 21D. 6 male pin base connectors are attached to the front frame panel as shown in figure 33C/D and figure 34C/D. 6 male pin base connectors are attached to the back frame panel as shown in figure 33C/D and figure 34C/D. 8 joint T pin holders are attached to the left frame panels as shown in figure 25D and figure 26D. 8 joint T pin holders are attached to the right frame panels as shown in figure 29D and figure 30D. There are 4 joint T pins on each side of the floor frame panel as shown in figure 6D, and figure 12D. There are 4 joint T pins on each side of the ceiling frame panel as shown in figure 16D, and figure 21D. The complete 20 foot high cube collapsible cargo container assembly is shown in figure 3D.

[248] During empty cargo container repositioning, an empty collapsible cargo container is disassembled into six component frame panels; those component frame panels are loaded into "shipping collapsible cargo container" (show in figure 1A, figure 1B, figure 1C and figure 1D), "shipping collapsible cargo container" is then shipped to its

destination. After “shipping collapsible cargo container” arrives at its destination, the disassembled component frame panels will remain in “shipping collapsible cargo container” until needed.

[249] By contacting base parts only (show in figure 37 and figure 38), “collapsible cargo container frame panel assembly” (show in figure 36A, figure 36B, figure 36C and FIG 36D) displaces its carried load at four corner points of “shipping floor frame panel” (show in figure 39A/C/D and figure 39B), which reduces said load impact on said “shipping floor frame panel” to the minimal.

[250] Through connectors (show in figure 53C and figure 53D), connect two 20-foot floor/ceiling frame panels into a 40 foot equivalent frame panel (show in figure 49C, figure 49D, figure 51C and figure 51D), which keeps load impact created by disassembled 20 foot collapsible cargo container frame panels behavior same as disassembled 40 foot ones.

[251] A machinery that is capable of holding , lifting, and positioning collapsible cargo container frame panels will be used to automate the collapsible cargo container disassembling, assembling, loading, and unloading process. 40-foot collapsible cargo containers are disassembled and loaded into a 40-foot collapsible cargo container as shown in figure 1A. 40-foot high cube collapsible cargo containers are disassembled and loaded into a 40-foot high cube collapsible cargo container as shown in figure 1B. 20-foot collapsible cargo containers are disassembled, connected as 40-foot equivalent (show in figure 49C and figure 51C) and loaded into a 40-foot collapsible cargo container as shown in figure 1C. 20-foot high cube collapsible cargo containers are

disassembled, connected as 40-foot equivalent(show in figure 49D and figure 51D) and loaded into a 40-foot collapsible cargo container as shown in figure 1D.

[252] figure 39A/C/D, figure 41A - figure 48A show the detailed step-by-step procedure to load disassembled 40 foot collapsible cargo container component frame panels into 40 foot collapsible cargo containers.

[253] figure 39B, figure 41B - figure 47B show the detailed step-by-step procedure to load disassembled 40 foot high cube collapsible cargo container component frame panels into 40 foot high cube collapsible cargo containers.

[254] figure 39A/C/D, figure 41C - figure 48C show the detailed step-by-step procedure to load disassembled 20 foot collapsible cargo container component frame panels into 40 foot collapsible cargo containers. figure 49C and figure 50C show two 20 foot ceiling frame panels connected into a 40 foot equivalent ceiling frame panel through the connector as shown in figure 53C. figure 51C and figure 52C show two 20 foot floor frame panels connected into a 40 foot equivalent floor frame panel through the connector as shown in FIG 53C.

[255] figure 39A/C/D, figure 41D - figure 47D show the detailed step-by-step procedure to load disassembled 20 foot high cube collapsible cargo container component frame panels into 40 foot collapsible cargo containers. figure 49D and figure 50D show two 20 foot high cube ceiling frame panels connected into a 40 foot equivalent ceiling frame panel through the connector as shown in figure 53D. figure 51D and figure 52D show two 20 foot high cube floor frame panels connected into a 40 foot equivalent floor frame panel through the connector as shown in FIG 53D.

[256] Compared to all those prior art cargo containers, the collapsible cargo container is simply consisted of six component frame panels; consequently the collapsible cargo container dissembling and assembling processes could be easily automated. Through special connectors, connect two 20-foot floor/ceiling frame panels into a 40-foot equivalent frame panel, load these 40-foot equivalent frame panels into 40-foot collapsible cargo container, it further reduces the empty collapsible cargo container repositioning cost. Furthermore, in the next structure analysis section, the analysis result shows (1) a 40-foot high cube collapsible cargo container can stand up load on its top which is 82 times of the container maximum gross weight, (2) loaded with 1.5 time container maximum weight (100,000LB), a 40-foot high cube collapsible cargo container maximum displacement in the floor longitudinal beams is just 0.584cm, the collapsible cargo container structure is proved to be as rigid as a traditional container.

2. The collapsible cargo container structure analysis

2.1 Overview

[257] JIFEX developed by Dalian University of Technology, is software providing the analysis and optimization of general finite elements, which is similar to ANSYS and NASTRAN. Dr. Guozhong Zhao, a Ph.D. in Engineering Mechanics, has used JIFEX to conduct the collapsible cargo container structure analysis, provided the structure analysis result including deformation and stress graphs. The analysis result proves that the collapsible cargo container has a rigid and reliable structure, can meet the logistics industry needs.

2.2 The collapsible cargo container structural model

[258] The 40 foot cargo container frame panel structure is modeled as shown in figure 58A/B. Its sizes are defined as follows:

L = 40 feet, L`= 2.5 feet, H = 8 feet 6 inches, W = 8 feet, W2 = 41 inches, W1 = W3 = 27.5 inches.

[259] The 40 foot high cube cargo container frame panel structure is modeled as shown in figure 58A/B. Its sizes are defined as the followings:

L = 40 feet, L`= 2.5 feet, H = 9.5 feet, W = 8 feet, W2 = 41 inches, W1 = W3 = 27.5 inches.

[260] The 20 foot cargo container frame panel structure is modeled as shown in figure 58C/D. Its sizes are defined as the followings:

L = 20 feet, L`= 1.25 feet, L`` = 2.5 feet, H = 8.5feet, W = 8 feet

[261] The 20 foot high cube cargo container frame panel structure is modeled as shown in figure 58C/D. Its sizes are defined as the followings:

L = 20 feet, L`= 1.25 feet, L`` = 2.5 feet, H = 9.5feet, W = 8 feet

2.3 The material property

[262] Material: Steel

Young's module: $E = 212Gp = 212\times10^9 N/m^2 = 212\times10^7 kg/(s^2 cm)$

Density: $\rho = 7860kg/m^3 = 0.007860kg/cm^3$

$\mu = 0.288$

$\sigma_s = 235Mp$

τ_p=140MP

2.4 The I-Beam, [-Beam and []-Beam

[263] The collapsible cargo container frame panel structure consists of I-beams, [-beams and []-beams as shown in figure 59.

The I-Beam is available in the following sizes:

- I-Beam(1): H=10cm, W=6.8cm, Th=0.76cm, Tw=0.45cm
- I-Beam(2): H=12.6cm, W=7.4cm, Th=0.84cm, Tw=0.5cm

The [-Beam is available in the following sizes:

- [-Beam(1): H=6.3cm, W=4cm, Th=0.75cm, Tw=0.48cm

The []-Beam is available in the following sizes:

- []-Beam(1): H=3cm, W=3cm, T=0.4cm
- []-Beam(2): H=18cm, W=10cm, T=0.8cm
- []-Beam(3): H=20cm, W=10cm, T=0.8cm

2.5 The 40 foot collapsible cargo container frame panel structures

[264] Reference: figure 60A/B

[-Beam(1) is the cross beam specified in the labels 2, 3, 5, 6, 8, 9, 11 and 12. []-Beam(1) is the vertical beam specified in the labels 4, 7 and 10. Four [-Beams(1) specified in each of the labels 14 and 15 reinforce the stability of the surrounding [-Beams(1). The vertical columns labeled as 1 and 13 are specially manufactured.

The specific size of these vertical columns is specified in figure 62 and figure 63.

[265] Reference: figure 64A/B

[]-Beam(3) is the longitudinal beam specified in the labels 1 and 2. I-Beam(2) is the transverse beams specified in the labels 3, 7, 11, 15, 18 and 19. I-Beam(1) is the transverse beams specified in the labels 4, 5, 6, 8, 9, 10, 12, 13 and 14. I-Beam(1) is the short transverse beams specified in the labels 16, 17, 20-25. The plate with its wall thickness equal to 0.3cm is labeled as 26.

[266] Reference: figure 65A/B

[]-Beam(2) is the longitudinal beam specified in the labels 1 and 2. I-Beam(2) is the edge transverse beams specified in the labels 3 and 7. [-Beam(1) is the edge transverse beams specified in the labels 4-6.

2.6 20 foot collapsible cargo container frame panel structure

[267] Reference: figure 60C/D

[-Beam(1) is the cross beam specified in the labels 2, 3, 5 and 6. []-Beam(1) is the vertical beam specified in the label 4. Four [-Beams(1) specified in each of the labels 8 and 9 reinforce the stability of the surrounding [-Beams(1). The vertical columns labeled as 1 and 7 are specially manufactured. The specific size of these vertical columns is specified in figure 62 and figure 63.

[268] Reference: figure 64C/D

[]-Beam(3) is the longitudinal beam specified in the labels 1 and 2. I-Beam(2) is the transverse beams specified in the labels 3, 9 and 15. I-Beam(1) is the transverse beams specified in the labels 4, 5, 6, 7, 8,10, 11, 12, 13 and 14.

[269] Reference: figure 65C/D

[]-Beam(2) is the longitudinal beam specified in the labels 1 and 2. I-Beam(2) is the edge transverse beams specified in the labels 3 and 5. [-Beam(1) is the edge transverse beams specified in the label 4.

2.7 The numerical result

2.7.1 The 40 foot cargo container structure simply supported at the floor corners

[270] The first load condition for the 40 foot collapsible cargo container frame is defined as the followings:

The 100,000 LB - distributed load on the floor is shown in figure 66A/B,

$100{,}000LB = 444520.16N = 44452016kg \cdot cm/s^2$ □where 11/16 of the distributed load ($30560761kg \cdot cm/s^2$) is on the part of the floor without an open gap, and 5/16 of the distributed load ($13891255kg \cdot cm/s^2$) is on the part of the floor with the open gap.

For each column, 83,750 LB-centralized loads applied at the ceiling end,

$83750LB = 372285.634N = 37228563.4kg \cdot cm/s^2$

The weight load is 6,947 LB or 3,088 kg,

$3088kg \times 9.80m/s^2 = 30262.4N = 3026240kg \cdot cm/s^2$

The deformation graph of the 40 foot cargo container frame panel structure is shown in figure 68A. The maximum displacement 1.6760cm is located in the floor. The maximum displacement in the floor longitudinal beams is 0.529cm.

[271] The second load condition for the 40 foot collapsible cargo container frame is defined as the followings:

The 67,200 LB distributed load on the floor is shown in figure 66A/B,

$67{,}200LB = 298717.55N = 29871755kg \cdot cm/s^2$, where 11/16 of the distributed load ($20536831.5625kg \cdot cm/s^2$) is on the part of the floor without the open gap, and 5/16 of the distributed load ($9334923.4375kg \cdot cm/s^2$) is on the part of the floor with the open gap.

For each column, 83,750 LB-centralized loads applied at the ceiling end,

$83750LB = 372285.634N = 37228563.4kg \cdot cm/s^2$

The weight load is 6,947 LB or 3,088 kg,

$3088kg \times 9.80m/s^2 = 30262.4N = 3026240kg \cdot cm/s^2$

The deformation graph of the 40 foot cargo container frame panel structure is shown in figure 69A. The maximum displacement 1.1619cm is located in the floor. The maximum displacement in the floor longitudinal beams is 0.378cm.

[272] The third load condition for the modified 40 foot collapsible cargo container frame panel structure is defined as the followings:

As shown in figure 61A/B and figure 67A/B, the front and back frames of the 40 foot collapsible cargo container frame panel structure have been replaced by six vertical columns, []-Beam(1), which connect the floor and ceiling longitude beams.

The total 50,000 LB centralized loads on the four floor corners are also shown in figure 67A/B,

$50000LB = 222260.08N = 22226008kg \cdot cm/s^2$, each corner has $5556502kg \cdot cm/s^2$.

The weight load is 6,947 LB or 3,088 kg,

$3088kg \times 9.80m/s^2 = 30262.4N = 3026240kg \cdot cm/s^2$

The deformation graph of the modified 40 foot cargo container frame panel structure is shown in figure 70A. The maximum displacement 1.1360cm is located in the floor. The maximum displacement in the floor longitudinal beams is also 1.1360cm.

2.7.2 The 40 foot cargo container structure simply supported at the ceiling corners

[273] The first load condition for the 40 foot collapsible cargo container frame is defined as the followings:

The 100,000 LB distributed load on the floor is shown in figure 66A/B,

$100{,}000LB = 444520.16N = 44452016kg \cdot cm/s^2$ □where 11/16 of the distributed load ($30560761kg \cdot cm/s^2$) is on the part of the floor without the open gap, and 5/16 of the distributed load ($13891255kg \cdot cm/s^2$) is on the part of the floor with the open gap.

For each column, 83,750 LB centralized loads applied at the floor end

$83750LB = 372285.634N = 37228563.4kg \cdot cm/s^2$

The weight load is 6,947 LB or 3,088 kg,

$3088kg \times 9.80m/s^2 = 30262.4N = 3026240kg \cdot cm/s^2$ and

The deformation graph of the 40 foot cargo container frame panel structure is shown in figure 71A, the maximum displacement 1.6869cm is located in the floor; the maximum displacement in the floor longitudinal beams is 0.500cm.

[274] The second load condition for the 40 foot collapsible cargo container frame is defined as the followings:

The 67,200 LB distributed load on the floor is shown in figure 66A/B,

$67{,}200LB = 298717.55N = 29871755kg \cdot cm/s^2$, in which, 11/16 of the distributed load ($20536831.5625kg \cdot cm/s^2$) is on the part of the floor without the open gap, and 5/16 of the distributed load ($9334923.4375kg \cdot cm/s^2$) is on the part of the floor with the open gap.

For each column, 83,750 LB centralized loads applied at the floor end,

$83750LB = 372285.634N = 37228563.4kg \cdot cm/s^2$

The weight load is 6,947 LB or 3,088 kg,

$3088kg \times 9.80m/s^2 = 30262.4N = 3026240kg \cdot cm/s^2$

The deformation graph of the 40 foot cargo container frame panel structure is shown in figure 72A, the maximum displacement 1.1750cm is located in the floor; the maximum displacement in the floor longitudinal beams is 0.355cm.

[275] The third load condition for modified the 40 foot collapsible cargo container frame panel structure is defined as the followings:

As the figure 61A/B and figure 67A/B shown, the front and back frames of the 40 foot collapsible cargo container frame panel structure have been replaced by six vertical columns, []-Beam(1), which connect the floor and ceiling longitude beams.

The total 50,000 LB centralized loads on the four floor corners are also shown in figure 67A/B,

$50000LB = 222260.08N = 22226008kg \cdot cm/s^2$, each corner has $5556502kg \cdot cm/s^2$.

The weight load is 6,947 LB or 3,088 kg,

$3088kg \times 9.80m/s^2 = 30262.4N = 3026240kg \cdot cm/s^2$ and

The deformation graph of the modified 40 foot cargo container frame panel structure is shown in figure 73A, the maximum displacement 1.1408cm is located in the floor; the maximum displacement in the floor longitudinal beams is also 1.1408cm.

2.7.3 The 40 foot high cube cargo container structure simply supported at the floor corners

[276] The first load condition for the 40 foot high cube collapsible cargo container frame is defined as the followings:

The 100,000 LB distributed load on the floor is shown in figure 66A/B,

$100{,}000LB = 444520.16N = 44452016 kg \cdot cm/s^2$ □where 11/16 of the distributed load ($30560761 kg \cdot cm/s^2$) is on the part of the floor without an open gap, and 5/16 of the distributed load ($13891255 kg \cdot cm/s^2$) is on the part of the floor with the open gap.

For each column, 83,750 LB centralized loads applied at the ceiling end,

$83750LB = 372285.634N = 37228563.4 kg \cdot cm/s^2$

The weight load is 7,012 LB or 3,117 kg,

$3117 kg \times 9.80 m/s^2 = 30546.6N = 3054660 kg \cdot cm/s^2$

The deformation graph of the 40 foot high cube cargo container frame panel structure is shown in figure 68B, the maximum displacement 1.7046cm is located in the floor; the maximum displacement in the floor longitudinal beams is 0.584cm.

[277] The second load condition for the 40 foot high cube collapsible cargo container frame is defined as the followings:

The 67,200 LB distributed load on the floor is shown in figure 66A/B,

$67{,}200LB = 298717.55N = 29871755kg \cdot cm/s^2$, where the 11/16 of the distributed load ($20536831.5625kg \cdot cm/s^2$) is on the part of the floor without the open gap, and 5/16 of the distributed load ($9334923.4375kg \cdot cm/s^2$) is on the part of the floor with the open gap.

For each column, 83,750 LB centralized loads applied at the ceiling end,

$83750LB = 372285.634N = 37228563.4kg \cdot cm/s^2$

The weight load is 7,012 LB or 3,117 kg,

$3117kg \times 9.80m/s^2 = 30546.6N = 3054660kg \cdot cm/s^2$

The deformation graph of the 40 foot high cube cargo container frame panel structure is shown in figure 69B, the maximum displacement 1.1823cm is located in the floor; the maximum displacement in the floor longitudinal beams is 0.414cm.

[278] The third load condition for the modified 40 foot high cube collapsible cargo container frame panel structure is defined as the followings:

As the figure 61A/B and figure 67A/B shown, the front and back frames of the 40 foot high cube collapsible cargo container frame panel structure have been replaced by six vertical columns, []-Beam(1), which connect the floor and ceiling longitude beams.

The total 50,000 LB centralized loads on the four floor corners are also shown in figure 67A/B,

$50000LB = 222260.08N = 22226008kg \cdot cm/s^2$, each corner has $5556502kg \cdot cm/s^2$.

The weight load is 7,012 LB or 3,117 kg,

$3117kg \times 9.80m/s^2 = 30546.6N = 3054660kg \cdot cm/s^2$

The deformation graph of the modified 40 foot high cube cargo container frame panel structure is shown in figure 70B, the maximum displacement 1.1501cm is located in the floor; the maximum displacement in the floor longitudinal beams is also 1.1501cm.

2.7.4 The 40 foot high cube cargo container structure simply supported at the ceiling corners

[279] The first load condition for the 40 foot high cube collapsible cargo container frame is defined as the followings:

The 100,000 LB distributed load on the floor is shown in figure 66A/B,

$100{,}000LB = 444520.16N = 44452016kg \cdot cm/s^2$ □where 11/16 of the distributed load ($30560761kg \cdot cm/s^2$) is on the part of the floor without the open gap, and 5/16 of the distributed load ($13891255kg \cdot cm/s^2$) is on the part of the floor with the open gap.

For each column, 83,750 LB centralized loads applied at the floor end,

$83750LB = 372285.634N = 37228563.4kg \cdot cm/s^2$

The weight load is 7,012 LB or 3,117 kg,

$3117kg \times 9.80m/s^2 = 30546.6N = 3054660kg \cdot cm/s^2$

The deformation graph of the 40 foot high cube cargo container frame panel structure is shown in figure 71B, the maximum displacement 1.7020cm is located in the floor; the maximum displacement in the floor longitudinal beams is 0.556cm.

[280] The second load condition for the 40 foot high cube collapsible cargo container frame is defined as the followings:

The 67,200 LB distributed load on the floor is shown in figure 66A/B,

$67{,}200LB = 298717.55N = 29871755kg \cdot cm/s^2$, in which, 11/16 of the distributed load ($20536831.5625kg \cdot cm/s^2$) is on the part of the floor without the open gap, and 5/16 of the distributed load ($9334923.4375kg \cdot cm/s^2$) is on the part of the floor with the open.

For each column, 83,750 LB centralized loads applied at the floor end,

$83750LB = 372285.634N = 37228563.4kg \cdot cm/s^2$

The weight load is 7,012 LB or 3,117 kg,

$3117kg \times 9.80m/s^2 = 30546.6N = 3054660kg \cdot cm/s^2$

The deformation graph of the 40 foot high cube cargo container frame panel structure is shown in figure 72B, the maximum displacement 1.1841cm is located in the floor; the maximum displacement in the floor longitudinal beams is 0.392cm.

[281] The third load condition for the modified 40 foot high cube collapsible cargo container frame panel structure is defined as the followings:

As the figure 61A/B and figure 67A/B shown, the front and back frames of the 40 foot high cube collapsible cargo container frame panel structure have been replaced by six vertical columns, []-Beam(1), which connect the floor and ceiling longitude beams.

The total 50,000 LB centralized loads on the four floor corners are also shown in figure 67A/B,

$50000LB = 222260.08N = 22226008kg \cdot cm/s^2$, each corner has $5556502kg \cdot cm/s^2$.

The weight load is 7,012 LB or 3,117 kg,

$3117kg \times 9.80m/s^2 = 30546.6N = 3054660kg \cdot cm/s^2$

The deformation graph of the modified 40 foot high cube cargo container frame panel structure is shown in figure 73B, the maximum displacement 1.1558cm is located in the floor; the maximum displacement in the floor longitudinal beams is also 1.1558cm.

2.7.5 The 20 foot cargo container structure simply supported at the four floor corners

[282] The first load condition for the 20 foot collapsible cargo container frame is defined as the followings:

The 100,000 LB distributed load on the floor is shown in figure 66C/D,

$100{,}000LB = 444520.16N = 44452016kg \cdot cm/s^2$

For each column, 83,750 LB centralized loads applied at the ceiling end,

$83750LB = 372285.634N = 37228563.4kg \cdot cm/s^2$

The weight load is 4,254 LB or 1981 kg,

$1891kg \times 9.80m/s^2 = 18531.8N = 1853180kg \cdot cm/s^2$

The first load deformation graph of the 20 foot cargo container frame panel structure is shown in figure 68C, the maximum displacement 1.5682cm is located in the floor; the maximum displacement in the floor longitudinal beams is 0.475cm.

[283] The second load condition for the 20 foot collapsible cargo container frame is defined as the followings:

The 67,200 LB distributed load on the floor is shown in figure 66C/D,

$67{,}200LB = 298717.55N = 29871755kg \cdot cm/s^2$, where the 11/16 of the distributed load ($20536831.5625kg \cdot cm/s^2$) is on the part of the floor without the open gap, and 5/16 of the distributed load ($9334923.4375kg \cdot cm/s^2$) is on the part of the floor with the open gap.

For each column, 83,750 LB centralized loads applied at the ceiling end,

$83750LB = 372285.634N = 37228563.4kg \cdot cm / s^2$

The weight load is 4,254 LB or 1981 kg,

$1891kg \times 9.80m / s^2 = 18531.8N = 1853180kg \cdot cm / s^2$

The deformation graph of the 20 foot cargo container frame panel structure is shown in figure 69C, the maximum displacement 1.0703cm is located in the floor; the maximum displacement in the floor longitudinal beams is 0.331cm.

[284] The third load condition for the modified 20 foot collapsible cargo container frame panel structure is defined as the followings:

As the figure 61C/D and figure 67C/D shown, the front and back frames of the 20 foot collapsible cargo container frame panel structure have been replaced by two vertical columns, []-Beam(1), which connect the floor and ceiling longitude beams.

The total 50,000 LB centralized loads on the four floor corners are also shown in figure 67C/D,

$50000LB = 222260.08N = 22226008kg \cdot cm / s^2$, each corner has $5556502kg \cdot cm / s^2$.

The weight load is 4,254 LB or 1981 kg,

$1891kg \times 9.80m / s^2 = 18531.8N = 1853180kg \cdot cm / s^2$

The deformation graph of the modified 20 foot cargo container frame panel structure is shown in figure 70C, the maximum displacement 0.21378cm is located in the floor; the maximum displacement in the floor longitudinal beams is also 0.21378.

2.7.6 The 20 foot cargo container structure simply supported at the ceiling corners

[285] The first load condition for the 20 foot collapsible cargo container frame is defined as the followings:

The 100,000 LB distributed load on the floor is shown in figure 66C/D,

$100{,}000LB = 444520.16N = 44452016 kg \cdot cm/s^2$ □where 11/16 of the distributed load ($30560761 kg \cdot cm/s^2$) is on the part of the floor without the open gap, and 5/16 of the distributed load ($13891255 kg \cdot cm/s^2$) is on the part of the floor with the open gap.

For each column, 83,750 LB centralized loads applied at the floor end,

$83750LB = 372285.634N = 37228563.4 kg \cdot cm/s^2$

The weight load is 4,254 LB or 1981 kg,

$1891 kg \times 9.80 m/s^2 = 18531.8N = 1853180 kg \cdot cm/s^2$

The deformation graph of the 20 foot cargo container frame panel structure is shown in figure 71C, the maximum displacement 1.5608cm is located in the floor; the maximum displacement in the floor longitudinal beams is 0.489cm.

[286] The second load condition for the 20 foot collapsible cargo container frame is defined as the followings:

The 67,200 LB distributed load on the floor is shown in figure 66C/D,

$67{,}200LB = 298717.55N = 29871755 kg \cdot cm/s^2$, in which, 11/16 of the distributed load ($20536831.5625 kg \cdot cm/s^2$) is on the part of the floor without the open gap, and 5/16 of the distributed load ($9334923.4375 kg \cdot cm/s^2$) is on the part of the floor with the open.

For each column, 83,750 LB centralized loads applied at the floor end,

$83750LB = 372285.634N = 37228563.4kg \cdot cm/s^2$

The weight load is 4,254 LB or 1981 kg,

$1891kg \times 9.80m/s^2 = 18531.8N = 1853180kg \cdot cm/s^2$

The deformation graph of the 20 foot cargo container frame panel structure is shown in figure 72C, the maximum displacement 1.0650cm is located in the floor; the maximum displacement in the floor longitudinal beams is 0.345cm.

[287] The third load condition for the modified 20 foot collapsible cargo container frame panel structure is defined as the followings:

As the figure 61C/D and figure 67C/D shown, the front and back frames of the 20 foot collapsible cargo container frame panel structure have been replaced by two vertical columns, []-Beam(1), which connect the floor and ceiling longitude beams.

The total 50,000 LB centralized loads on the four floor corners are also shown in figure 67C/D,

$50000LB = 222260.08N = 22226008kg \cdot cm/s^2$, each corner has $5556502kg \cdot cm/s^2$.

The weight load is 4,254 LB or 1981 kg,

$1891kg \times 9.80m/s^2 = 18531.8N = 1853180kg \cdot cm/s^2$

The deformation graph of the modified 20 foot cargo container frame panel structure is shown in figure 73C, the maximum displacement 0.21922cm is located in the floor; the maximum displacement in the floor longitudinal beams is also 0.21922cm.

2.7.7 The 20 foot high cube cargo container structure simply supported at the floor corners

[288] The first load condition for the 20 foot high cube collapsible cargo container frame is defined as the followings:

The 100,000 LB distributed load on the floor is shown in figure 66C/D,

$100{,}000LB = 444520.16N = 44452016kg \cdot cm/s^2$

For each column, 83,750 LB centralized loads applied at the ceiling end,

$83750LB = 372285.634N = 37228563.4kg \cdot cm/s^2$

The weight load is 4,355 LB or 1936 kg,

$1936kg \times 9.80m/s^2 = 18972.8N = 1897280kg \cdot cm/s^2$

The deformation graph of the 20 foot high cube cargo container frame panel structure is shown in figure 68D, the maximum displacement 1.5712cm is located in the floor; the maximum displacement in the floor longitudinal beams is 0.486cm.

[289] The second load condition for the 20 foot high cube collapsible cargo container frame is defined as the followings:

The 67,200 LB distributed load on the floor is shown in figure 66C/D,

$67{,}200LB = 298717.55N = 29871755kg \cdot cm/s^2$

For each column, 83,750 LB centralized loads applied at the ceiling end,

$83750LB = 372285.634N = 37228563.4kg \cdot cm/s^2$ and

The weight load is 4,355 LB or 1936 kg,

$1936kg \times 9.80m/s^2 = 18972.8N = 1897280kg \cdot cm/s^2$

The deformation graph of the 20 foot high cube cargo container frame panel structure is shown in figure 69D, the maximum displacement 1.0735cm is located in the floor; the maximum displacement in the floor longitudinal beams is 0.339cm.

[290] The third load condition for the modified 20 foot high cube collapsible cargo container frame panel structure is defined as the followings:

As the figure 61C/D and figure 67C/D shown, the front and back frames of the 20 foot high cube collapsible cargo container frame panel structure have been replaced by two vertical columns, []-Beam(1), which connect the floor and ceiling longitude beams.

The total 50,000 LB centralized loads on the four floor corners are also shown in figure 67C/D,

$50000LB = 222260.08N = 22226008kg \cdot cm/s^2$, each corner has $5556502kg \cdot cm/s^2$.

The weight load is 4,355 LB or 1936 kg,

$1936kg \times 9.80m/s^2 = 18972.8N = 1897280kg \cdot cm/s^2$

The deformation graph of the modified 20 foot high cube cargo container frame panel structure is shown in figure 70D, the maximum displacement 0.22369cm is located in the floor; the maximum displacement in the floor longitudinal beams is also 0.22369cm.

2.7.8 The 20 foot high cube cargo container structure simply supported at the ceiling corners

[291] The first load condition for the 20 foot high cube collapsible cargo container frame is defined as the followings:

The 100,000 LB distributed load on the floor is shown in figure 66C/D,

$100,000LB = 444520.16N = 44452016kg \cdot cm/s^2$

For each column, 83,750 LB centralized loads applied at the floor end,

$83750LB = 372285.634N = 37228563.4kg \cdot cm/s^2$

The weight load is 4,355 LB or 1936 kg,

$$1936kg \times 9.80m/s^2 = 18972.8N = 1897280kg \cdot cm/s^2$$

The deformation graph of the 20 foot high cube cargo container frame panel structure is shown in figure 71D, the maximum displacement 1.5678cm is located in the floor; the maximum displacement in the floor longitudinal beams is 0.500cm.

[292] The second load condition for the 20 foot high cube collapsible cargo container frame is defined as the followings:

The 67,200 LB distributed load on the floor is shown in figure 66C/D,

$$67{,}200LB = 298717.55N = 29871755kg \cdot cm/s^2$$

For each column, 83,750 LB centralized loads applied at the floor end,

$$83750LB = 372285.634N = 37228563.4kg \cdot cm/s^2$$

The weight load is 4,355 LB or 1936 kg,

$$1936kg \times 9.80m/s^2 = 18972.8N = 1897280kg \cdot cm/s^2$$

The deformation graph of the 20 foot high cube cargo container frame panel structure is shown in figure 72D, the maximum displacement 1.0719cm is located in the floor; the maximum displacement in the floor longitudinal beams is 0.354cm.

[293] The third load condition for the modified 20 foot high cube collapsible cargo container frame panel structure is defined as the followings:

As the figure 61C/D and figure 67C/D shown, the front and back frames of the 20 foot collapsible cargo container frame panel structure have been replaced by two vertical columns, []-Beam(1), which connect the floor and ceiling longitude beams.

The total 50,000 LB centralized loads on the four floor corners are also shown in figure 67C/D,

$50000LB = 222260.08N = 22226008kg \cdot cm/s^2$, each corner has $5556502kg \cdot cm/s^2$.

The weight load is 4,355 LB or 1936 kg,

$1936kg \times 9.80m/s^2 = 18972.8N = 1897280kg \cdot cm/s^2$

The deformation graph of the 20 foot high cube cargo container modified frame panel structure is shown in figure 73D, the maximum displacement 0.22979 is located in the floor; the maximum displacement in the floor longitudinal beams is also 0.22979.

2.8 The inner force of the crossbeams

[294] 40 foot collapsible cargo container frame panel structure:

The inner forces of the crossbeams in the front/back frame panels are listed in Table 1A. Each beam in the front/back frame panels is labeled in figure 65A/B.

[295] 40 foot high cube collapsible cargo container frame panel structure:

The inner forces of the crossbeams in the front/back frame panels are listed in Table 1B. Each beam in the front/back frame panels is labeled in FIG 65A/B.

[296] 20 foot collapsible cargo container frame panel structure:

The inner forces of the crossbeams in the front/back frame panels are listed in Table 1C. Each beam in the front/back frame panels is labeled in figure 65C/D.

[297] 20 foot high cube collapsible cargo container frame panel structure:

The inner forces of the crossbeams in the front/back frame panels are listed in Table 1D. Each beam in the front/back frame panels is labeled in figure 65C/D.

2.9 The inner force of the vertical beams

[298] 40 foot collapsible cargo container:

The inner forces of the vertical beam in the front/back frame panels are listed in Table 2A. Each beam is labeled in figure 61A/B.

[299] For the 40 foot high cube collapsible cargo container, the inner forces of the vertical beam in the front/back frame panels are listed in the Table 2B, each beam is numbered as the figure 61A/B shown.

[300] For the 20 foot collapsible cargo container, the inner force of the vertical beam in the front/back frame panels is listed in the Table 2C, each beam is numbered as the figure 61C/D shown.

[301] For the 20 foot high cube collapsible cargo container, the inner force of the vertical beam in the front/back frame panels is listed in the Table 2D, each beam is numbered as the figure 61C/D shown.

2.10 Column and beam stability analysis

[302] The formula used to compute the stability of column/beam simply supported at two ends:

$$P_l = k\pi^2 \frac{EI}{l^2}, k = 1.0$$

Where: E——young's modulus I——inertia moment l——Length

2.10.1 Stability analysis for column (height = 8 foot 6 inch)

[303] The critical load of the column with the cross section as shown in figure 62

$$E = 212Gp = 212\times10^9 N/m^2 = 212\times10^7 kg/(s^2cm)$$

$$I_x = 2.485\mathrm{e}+003cm^4$$

$l = 259cm$

$$P_l = 1.0 \times 3.14^2 \times \frac{212 \times 10^7 \times 2.485 \times 10^3}{259^2} = 7.7432e + 008 kg \cdot cm / s^2$$

$$= 7.7432e + 006N = 1.7422e + 006LB$$

Based on the maximum gross weight 67,400 LB for the structure, the column critical load is 103 times of the maximum gross weight.

[304] The critical load of the column with the cross section as shown in figure 63

$E = 212Gp = 212 \times 10^9 N / m^2 = 212 \times 10^7 kg /(s^2 cm)$

$I_x = 2.300e + 003cm^4$

$l = 259cm$

$$P_l = 1.0 \times 3.14^2 \times \frac{212 \times 10^7 \times 2.300 \times 10^3}{259^2} = 7.1668e + 008 kg \cdot cm / s^2$$

$$= 7.1668e + 006N = 1.6125e + 006LB$$

Based on the maximum gross weight 67,400 LB for the structure, the column critical load is 95 times of the maximum gross weight.

2.10.2 Stability analysis for column (height = 9 foot 6 inch)

[305] The critical load of the column with the cross section as shown in figure 62

$E = 212Gp = 212\times10^{9} N/m^{2} = 212\times10^{7} kg/(s^{2}cm)$

$I_x = 2.485\mathrm{e}+003cm^{4}$

$l = 289.56cm$

$$P_l = 1.0\times3.14^{2}\times\frac{212\times10^{7}\times2.485\times10^{3}}{289.56^{2}} = 6.1950\mathrm{e}+008kg\cdot cm/s^{2}$$

$$= 6.1950\mathrm{e}+006N = 1.3939\mathrm{e}+006LB$$

Based on the maximum gross weight 67,400 LB for the structure, the column critical load is 82 times of the maximum gross weight.

[306] The critical load of the column with the cross section as shown in figure 63

$E = 212Gp = 212\times10^{9} N/m^{2} = 212\times10^{7} kg/(s^{2}cm)$

$I_x = 2.300\mathrm{e}+003cm^{4}$

$l = 289.56cm$

$$P_l = 1.0\times3.14^{2}\times\frac{212\times10^{7}\times2.300\times10^{3}}{289.56^{2}} = 5.7338\mathrm{e}+008kg\cdot cm/s^{2}$$

$$= 5.7338\mathrm{e}+006N = 1.2901\mathrm{e}+006LB$$

Based on the maximum gross weight 67,400 LB for the structure, the column critical load is 76 times of the maximum gross weight.

[307] The above analysis shows that four columns of the collapsible cargo container and high cube collapsible cargo container will be able to bear extremely large vertical loads.

2.10.3 Stability analysis for the crossbeams when $l = 100cm$

[308] $E = 212Gp = 212\times10^{9} N/m^{2} = 212\times10^{7} kg/(s^{2}cm)$

$I_x = 11.9\, cm^4$

$l = 100cm$

$$P_l = 1.0 \times 3.14^2 \times \frac{212 \times 10^7 \times 11.9}{100^2} = 2.4874 \times 10^7\, kg \cdot cm / s^2$$

$$= 2.4874 \times 10^5\, N = 5.5966 \times 10^4\, LB$$

The values for crossbeam 3 and 11 specified in Table 1A and Table 1B are below the maximum limit defined by P_l . Therefore, crossbeam 3 and 11 meet the stability requirement. The values for crossbeam 3 and 5 specified in Table 1C and Table 1D are below the maximum limit defined by P_l . Therefore, crossbeam 3 and 5 meet the stability requirement.

2.10.4 Stability analysis for the crossbeams when $l = 200cm$

[309] $E = 212Gp = 212 \times 10^9\, N / m^2 = 212 \times 10^7\, kg / (s^2 cm)$

$I_x = 11.9\, cm^4$

$l = 200cm$

$$P_l = 1.0 \times 3.14^2 \times \frac{212 \times 10^7 \times 11.9}{200^2} = 6.2184 \times 10^6\, kg \cdot cm / s^2$$

$$= 6.2184 \times 10^4\, N = 1.3992 \times 10^4\, LB$$

The values for crossbeam 6 and 8 specified in Table 1A and Table 1B are below the maximum limit defined by P_l. Therefore, crossbeam 6 and 8 meet the stability requirement.

2.10.5 Stability analysis for the vertical beam when $l = 259cm$

[310] $E = 212Gp = 212 \times 10^9 N/m^2 = 212 \times 10^7 kg/(s^2 cm)$

$I_x = 4.8\, cm^4$

$l = 259cm$

$$P_l = 1.0 \times 3.14^2 \times \frac{212 \times 10^7 \times 4.8}{259^2} = 1.4957 \times 10^6 kg \cdot cm/s^2$$

$$= 1.4957 \times 10^4 N = 3.3653 \times 10^3 LB$$

The value for vertical beam 2 specified in Table 2A and Table 2B is below the maximum limit defined by P_l. Therefore, vertical beam 2 meets the stability requirement.

2.10.6 Stability analysis for the ceiling longitudinal beam simply supported at two ends when $l = 1219cm$

[311] $E = 212Gp = 212 \times 10^9 N/m^2 = 212 \times 10^7 kg/(s^2 cm)$

$I_x = 651.132\, cm^4$

$l = 1219cm$

$$P_l = 1.0 \times 3.14^2 \times \frac{212 \times 10^7 \times 651.132}{1219^2} = 9.1592 \times 10^6 kg \cdot cm / s^2$$

$$= 9.1592 \times 10^4 N = 2.0608 \times 10^4 LB$$

When the collapsible cargo container frame panel structure is simply supported at four floor corners with only six vertical beams in the front and back frames to connect the floor and ceiling longitudinal beams, the ceiling longitudinal beam inner force is

$$-2.5964e+004 \text{ N} = -5.8419e+003 \text{ LB}$$

The value for ceiling longitudinal beam inner force is below the maximum limit defined by P_l . Therefore, the ceiling longitudinal beam meets the stability requirement.

2.10.7 Stability analysis for the ceiling longitudinal beam when $l = 609.6cm$ and it is simply supported at two ends

[312] $E = 212Gp = 212 \times 10^9 N/m^2 = 212 \times 10^7 kg/(s^2 cm)$

$I_x = 651.132\, cm^4$

$l = 609.6cm$

$$P_l = 1.0 \times 3.14^2 \times \frac{212 \times 10^7 \times 651.132}{609.6^2} = 3.6625 \times 10^7 kg \cdot cm / s^2$$

$$= 3.6625 \times 10^5 N = 8.2406 \times 10^4 LB$$

When the collapsible cargo container frame panel structure is simply supported at four floor corners with only two vertical beams in the front and back frames to connect the floor and ceiling longitudinal beams, the ceiling longitudinal beam inner force is

$$-9.5011e+003\text{N} = -2.1377e+003\,\text{LB}$$

Comparing P_l value with the ceiling longitudinal beam inner force value above, the ceiling longitudinal beam certainly meets the stability requirement.

3 Joint connector part analysis

3.1 Joint T pin holder analysis

[313] The joint T pin holder is shown in figure 74, where variable X is in the range 5cm to 7cm. Its related load condition is also as shown in figure 74.

Under 100,000 LB load condition, assuming the load is evenly distributed on the joint T pin holder surface:

For the joint T pin holder at the floor level, the load Px is 4.6971e+004N (10438LB), and the load Pz is 5.4e+004N (12000 LB).

For the joint T pin holder at the ceiling level, the load Px is 1.4446e+004N (3210 LB), and the load Pz is 3.0713e+004N (6813LB).

From the stress contour graph figure 75 and figure 76, the results show that the floor level joint T pin holder maximum Mises stress is 148.13MP and the ceiling level joint T pin holder maximum Mises stress is 75.37MP.

[314] Finite element analysis is conducted for the shaded part of the joint T pin holder as shown in figure 77. The load Px for the floor level and ceiling level shadowed part are 4.6971e+004N (10438LB) and 1.4446e+004N (3210 LB) respectively. The finite element

analysis results show the floor level joint T pin holder maximum Mises stress is 166.56MP in figure 78 and the ceiling level joint T pin maximum Mises stress is 55.55MP in figure 79.

3.2 Male pin base and female pin base analysis

[315] The male pin base is shown in figure 80, where

x_1 = 1.75cm, x2 = 2.5cm, d = 3.0cm, $y_1 = y_2$ = 1.75cm

Less than 100,000 LB load, the load Px for the male pin base is 14050.825N (3122LB), and the load Py is 15572.25N (3460 LB), as shown in figure 81. From the stress contour graph figure 82, the results show that the male pin base maximum Mises stress is 115.62MP.

figure 83 and figure 84 show the male pin base deformation in X and Y orientation respectively.

[316] The female pin base is shown in figure 85, where

x_1 = 1.75cm, x2 = 2.5cm , d = 3.0cm, $y_1 = y_2$ = 1.75cm, w_1 = 4cm

Less than 100,000 LB load, the load Px for the female pin base is 7025.4125N (1561LB), and the load Py is 7786.125N (1730 LB), as shown in figure 86. From the stress contour graph figure 87, the results show that the female pin base maximum Mises stress is 77.55MP. figure 88 and figure 89 show the female pin base deformation in X and Y orientation respectively.

3.3 Pin analysis

[317] The stress analysis of the pin, which is used to connect the male pin base and female

pin base, is based on the following formula

a. $\tau = \dfrac{4F_l}{\pi D^2 Z}$

where

F_l = 85000N, D = 3.5cm = 0.035m, Z = 2,

Based on the material properties defined in section 2.3,

τ < 45Mp

$\tau < \tau_p$ < 140Mp

Therefore the pin is suitable.